An earlier version appeared in *Pyrotechnics Guild International Bulletin*, No. 85 (1993).

Aluminum Metal Powders in Pyrotechnics

K.L. and B.J. Kosanke

[This article is an updated, enlarged version of one originally appearing in *Pyrotechnics Guild International Bulletin* Nos. 27 and 28 (1981–82).]

Of those chemicals used in pyrotechnics (with the possible exception of charcoal) aluminum metal powders have the ability to produce the greatest variety and range of effects. Thus, mastery of the use of aluminum in pyrotechnics offers both a challenge and a reward. In an attempt to assist in achieving that mastery, this article presents information on aluminum metal powders and their use in pyrotechnics. However, the emphasis is on physical aspects of aluminum metal powders, rather than on aluminum chemistry. The subject of specific uses of aluminum in pyrotechnics has been covered by other authors, and numerous references to such articles are given in the last section of this paper.

A) Background Information

Aluminum is the third most abundant element found in the Earth's crust (8.13%). It derives its name from alumen, which is Latin for alum (aluminum sulfate). Because aluminum has a great affinity for oxygen, it does not occur naturally as the pure metal. Aluminum is produced in an energy intensive two step process from the natural ore Bauxite, which is a mixture of minerals rich in hydrated aluminum oxides. In the first step (Bayer Process) the Bauxite is refined to alumina (aluminum oxide). In the second (Hall-Heroult Process) the alumina is electrolytically reduced to molten aluminum metal.

From a chemical standpoint, aluminum is very reactive; so much so that particles of aluminum metal become coated with aluminum oxide almost instantly when exposed to air. The formation of an oxide coating is not unusual for a reactive metal; what is unusual is the extent to which aluminum's oxide coating protects the metal from further chemical attack. In most circumstances, aluminum powders behave quite stably in pyrotechnic compositions. However, there are occasions when unwanted (unexpected) reactions have had disastrous consequences. See References 1 and 2 for an introduction to aluminum's potential for undesirable reactivity in damp compositions. In the authors' research and as reported in the literature, it has been shown that weak acids (such as boric acid), potassium dichromate, and silicates tend to passivate aluminum's water reactivity, whereas all bases and many strong acids increase aluminum's reactivity. In all cases this seems to be a result of either a strengthening or an eroding of the protective oxide coating on the aluminum particles.

B) General Descriptive Terms: Dark, Light, and Bright

The authors suggest that the use of these terms be avoided as being too general to sufficiently describe the wide range of aluminum metal powders presently in use. Also, today, they have come to mean different things to different people, sometimes leading to confusion and poor results. The differences in effects produced by various aluminum powders are profound, and even subtle differences, not easily detectable by eye or feel, can produce significantly different results.

Historically, "dark" referred to extremely fine flake aluminum, because finer flakes generally appear darker. This is a consequence of light scattering from the more numerous irregular particle surfaces. However, an exception is "German dark" aluminum. Here much of the dark appearance results from the presence of carbon, produced during its manufacture (discussed further below). Sometimes different grades of German dark aluminum have been described as Yellow-Head, Blue-Head and Black-Head, all appearing quite dark because of the carbon, but each having different particle sizes. Thus, at least in the case of German dark aluminums, darkness of appearance is not a useful guide to particle size.

To most pyrotechnists, "bright", not light, is the opposite of the attribute dark. Bright also refers to flake aluminum, but in this case the flakes are large enough (and free of carbon) to appear shiny bright. This effect is enhanced if the flakes are coated with stearin or similar material in the manufacturing process. Although bright alumi-

Table 1. Mesh and Particle Sizes, with Examples.

US Standard * Sieve Mesh No.	Space between Wires Inches	Microns**	Typical Material
14	0.056	1400	Coarse sand
28	0.028	700	Beach sand
60	0.0098	250	Fine sand
100	0.0059	150	Popcorn salt
***			
200	0.0030	74	Portland cement
325	0.0017	44	Silt
400	0.0015	37	Plant pollen
(600)	0.0010	25	
(1200)	0.0005	12	Red blood cell
(2400)	0.0002	6	
(4800)	0.0001	2	Cigarette smoke

* The mesh numbers in parentheses do not exist as actual sieves; they are included for comparative reference. For this reason, mesh numbers greater than 325 or 400 are sometimes referred to as "sub-mesh" sizes.

** One micron is a unit of length equaling 1 millionth of a meter (about 1/25,000 of an inch). It is a convenient and frequently used unit to use in describing fine powders.

*** For most people, somewhere between 100 and 200-mesh, powders become "impalpable". Their particles are so small they cannot be felt when a small sample is rubbed lightly between the fingers.

num powders are generally larger in particle size than dark aluminums, it must be noted that bright flake aluminum can still be extremely fine and dangerously reactive. Indeed, most flash powders found in Chinese firecrackers contain "bright" aluminum powder.

"Light" usually refers to atomized aluminum metal powders. The particles have a much more 3-dimensional character than flakes. Unfortunately, confusion can arise because some "light" atomized aluminum powders can appear as dark as "dark" flake aluminum, and yet are tremendously less reactive.

It is felt that confusion in describing aluminum metal powders can be avoided by using the more descriptive terms "flake" and "atomized", along with an indication of particle size. Possibly the one exception to this rule is the use of the special term "flitters", which are gigantic flakes, usually in the range of 10 to 80 mesh.

C) Particle Size Descriptions

Probably the method most commonly used to describe particle size is the specification of the sieve mesh number (screen) that either passes or retains the particles in question. Here mesh number refers to the number of strands per inch (of standard-diameter wire) used to make screen cloth (i.e., 10-mesh screen has ten wires per inch). Note that this means that 1/10-inch particles will not pass a 10-mesh screen because of the width taken by the wire. The diameter of wire used depends on mesh size (i.e., 100-mesh screen has very fine wire as compared to 10-mesh screen). A complicating factor is that there are at least two sets of "standard" and many non-standard wire sizes in use; this means not all 50-mesh screens have the same size gap between their wires. However, the difference is generally not so great as to cause serious problems. Table 1 lists the more commonly used "US Standard" mesh numbers and the resulting space between their wires.

The concept of mesh size seems simple, but exactly what does it mean to describe an aluminum powder as 100 mesh? For any commercially produced powder, individual particle sizes range widely, sometimes extremely widely. Thus it obviously does not mean that each of the particles are exactly 0.0059 inches in diameter. Does it mean that all particles will pass through a 100-mesh screen? It means that to some people, but others say it means that 99%, 90% or even 50% of the material will pass through a 100-mesh screen. Probably the best way to use mesh size is to specify the percentage by weight that passes through one size mesh screen but fails to pass another finer mesh screen. For example, a powder might be described as 95% passing 50-mesh but retained on

150-mesh screen. To be more complete, it would be better to include information on how the particle sizes are distributed throughout a broad range. For example, 3% is +50 mesh, 20% is in the range from –50 to +80, 40% is from –80 to +120, 35% is –120 to +150, and 2% is –150. (In this case, the "+" sign means "fails to pass" or is larger than the specified mesh, and the "–" sign means "passes" or is smaller than the specified mesh.) Such a complete description of the range of particle sizes is lengthy and perhaps offers more information than is actually necessary for most pyrotechnic uses.

As a practical matter, when only a single mesh number is given, such as 325 mesh, it can be assumed that at least half of the material will pass that mesh screen. When a single "+" or "–" mesh number is given, such as +200 mesh or –400 mesh, it can be assumed that most of the material will be "retained on" or "will pass through" that mesh screen, respectively. When a pair of mesh numbers is given, such 100–200 mesh, it can be assumed that most of the material will pass the courser screen but will be retained on the finer screen.

A brief alternative to specifying a single mesh number, but offering slightly more information, is to give the average particle size for a powder. For example, an aluminum powder might be described as having an average particle size of 5 microns. That can be taken to mean that about half of the weight of material is composed of particles larger than 5 microns and about half smaller than 5 microns. Note that a micron is a millionth of a meter or about .0025 inch and is sometimes abbreviated "µ".

D) Aluminum Manufacturing Processes

There are three different manufacturing processes for aluminum metal powder, plus some significant variations. The first is simply grinding or shredding the material. This method is no longer very common and cannot be used to make the smallest particle size aluminum powders. A ground aluminum powder has a granular appearance, with edges and points appearing quite sharp when viewed under magnification.

Probably the most common method of producing aluminum powders is by atomization. In this case, molten aluminum is sprayed into a gas stream, where the droplets solidify as they fall to a collecting area. A wide range of particle sizes can be made using the atomization process. For example, some of the most fine and most coarse aluminum powders used in pyrotechnics are produced by atomization. One method for separating different sizes of atomized aluminum particles during manufacture is to use air currents, in a process similar to separating wheat from chaff.

When viewed under magnification, all atomized aluminum particles have a roundish appearance, although the degree of roundness can vary greatly. If aluminum droplets are sprayed into an inert atmosphere, surface tension and viscosity will cause them to form fairly perfect spheres before the particles solidify. This material would be described as "spherical" atomized powder. In other instances, the droplets are sprayed into air, which causes a heavy oxide coating to immediately form on the surface of the still molten particles. This acts to quickly freeze the particles into spheroids, somewhat like footballs and door knobs.[3] This material would be described as "spheroidal" atomized powder. See Photos 1 and 2 for examples of spherical and spheroidal aluminum powders. In some cases the particles can have a highly angular appearance. Aluminum produced in this manner is usually quite coarse and appears very much like ground aluminum. The difference being that the angular points and edges appear slightly rounded, not sharp, when viewed under magnification. Sometimes this type of atomized aluminum is referred to as "blown" aluminum (term not recommended). These three different types of atomized aluminum can behave rather differently in pyro-chemical reactions. For that reason the shape of atomized aluminum (i.e., spherical, spheroidal or granular should be included in a complete description).

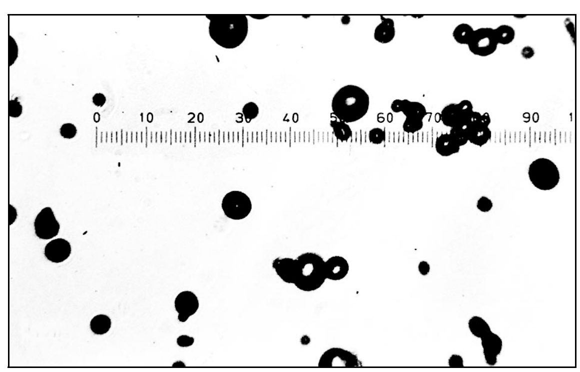

Photo 1. Photomicrograph of 30 micron spherical atomized aluminum powder; each scale division is 10 microns.

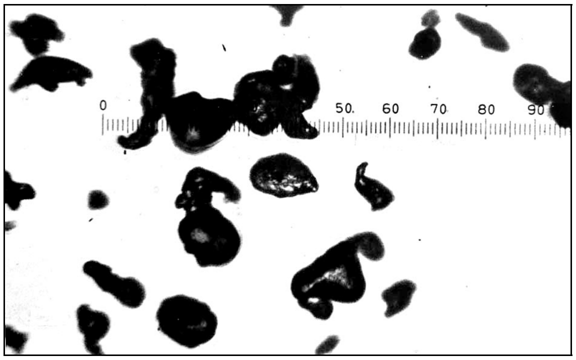

Photo 2. Photomicrograph of 20 micron spheroidal atomized aluminum powder (Alcoa 101,); each scale division is 2.4 microns.

The third manufacturing process produces flake aluminum. In this case, aluminum particles or foils are either rolled or hammered into very thin flakes, see Photo 3. In any event, a lubricant must be added to the aluminum to prevent the flakes from sticking together and onto the rollers or hammers. Stearic and oleic acid, constituents of natural fats, are commonly used as the lubricant. The presence of the lubricant often gives flake aluminum a slippery feel, and is the reason it resists mixing with water in star compositions. It can also cause the powder to appear extremely shiny. As a note of caution, the removal of the lubricant should never be attempted. This can expose fresh or only partly oxidized metal surfaces on the particles. The resulting air oxidation can lead to self heating of the aluminum powder with potentially dangerous consequences.

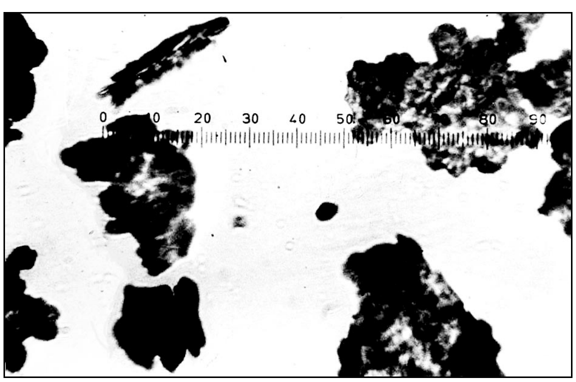

Photo 3. Photomicrograph of 36 micron flake aluminum powder (Alcan 3100); each scale division is 2.4 microns.

One significant variation in manufacturing flake aluminum accounts for much of the dark color in German dark aluminum. Here little or no lubricant is used. Instead the aluminum is rolled on or between very thin sheets of paper. After the rolling process, the material is heated, turning the paper to carbon. German dark aluminum can contain as much as 2.5% carbon.

E) Effect of Particle Size and Shape on Chemical Reactivity

Pyrotechnic reactivity is a poorly defined term, it is generally taken to mean a combination of how easy it is to initiate a reaction and how rapidly it will proceed once initiated. All else being equal, the smaller the particle size of the aluminum, the more reactive it will be. This is the case because pyro-chemical reactions begin on surfaces of particles, where fuel particles are in contact with oxidizer particles. Thus, the more surface area there is for a given weight of material, the more points of fuel to oxidizer contact exist, and the easier it is to initiate and propagate the chemical reaction. As an example of the difference in surface area between equal weights of different aluminum powders, note that 5 micron (–400 mesh) particles have 30 times the surface area as the same weight of 150 micron (50–150 mesh) particles of the same general shape.

Another particle characteristic that influences reactivity is particle shape. Particles with sharp angular shapes are more reactive than those with spherical shapes. In part, this is a surface area effect; angular particles have greater surface area than round particles of the same diameter. However, another reason is the sharp points and edges themselves, which tend to heat up easier (faster) than the bulk of the particle. Thus making it easier for chemical reactions to begin at those places.

Flake particles represent an extreme with regard to surface area and also ease of heating. They can easily have more than 10 times the surface area of an equal size atomized particle. Accordingly, flakes will generally be the most reactive for their particle size. The reason this is not universally true is that the flakes, which are protected with large amounts of lubricant, are made less reactive by that coating.

F) Uses for Different Aluminum Powders

In order to produce the full range of pyrotechnic effects, it is necessary to use of several particle sizes and different forms of aluminum metal powders. This is because aluminum metal powders range so extensively in their pyrotechnic perfor-

Table 2. Specifications for a Collection of Aluminum Metal Powders Useful in Producing a Wide Range of Pyrotechnic Effects.

Aluminum Description	Manufacturer and Product Number
Flake Aluminums:	
Coarse Flitters (flake 10–28 mesh)	Obron 41813/6
Fine Flitters (flake 20–80 mesh)	US Aluminum (Bronze) 813
Flake (–325 mesh, 36 micron)	Alcan 2000 (formerly, Alcoa 9880)
Flake (13 micron, American Dark)	Alcan 7100 (formerly, Obron 10890)
Flake (3 micron, German Dark)	Obron 5413
Atomized Aluminums:	
Granular (50–150 mesh)	Alcoa 1222
Spherical (325 mesh, 30 micron)	Mfg. Unknown
Spheroidal (–325 mesh, 20 micron)	Alcoa 101 (Alcoa 130, soon)
Spherical (400 mesh, 12 micron)	Alcoa S-10
Spherical (–400 mesh, 5 micron)	Reynolds 400 (formerly, Reynolds 131)

mance, it is simply not possible to achieve a variety of high quality results using only one or two aluminum powders. Table 2 lists a collection of aluminum powders useful in pyrotechnics. Along with descriptions of the powders are manufacturer names and their product numbers. Where the supplier for these materials has changed recently, that manufacturer information is also included.

Table 3 lists some of the ways in which aluminum metal powders are used in pyrotechnics. It is not intended to imply that these are the only uses for these aluminum powders; and, most especially, it is not intended to imply that these are the only aluminum powders suitable for the applications listed. Because the performance of powders, even those with similar specifications, sometimes perform quite differently, only those products with which the authors have had experience are included below. However, it is recognized that it would be useful to include information on the products of other manufacturers; thus some additional information supplied by M. Swisher on oth-

Table 3. Common Uses for the Aluminum Metal Powders Listed in Table 2.

Aluminum Description	Common Usage	Effect	Notes
Coarse Flitters (Flake, 10–28 mesh)	Stars, waterfalls and fountains	Persistent burning white sparks	(a)
Fine Flitters (Flake, 20–80 mesh)	Stars, waterfalls and fountains	Persistent burning white sparks	(a)
Flake (–325 mesh, 36 micron)	Stars and fountains	Short burning white sparks	(a)
	Large salutes	Sound (Report)	(b)
Flake (13 micron, American Dark)	Medium salutes	Sound (Report)	(b)
Flake (3 micron, German Dark)	Small salutes	Sound (Report)	(b)
Granular (50–150 mesh)	Comet stars and fountains	Persistent burning white sparks	(a)
Spherical (325 mesh, 30 micron)	Glitter stars and fountains	Delayed trailing white or gold flashes	(c)
Spheroidal (–325 mesh, 20 micron)	Metal fuel in stars, etc.	Flame brightening	(d)
Spheroidal (400 mesh, 12 micron)	Glitter stars and fountains	Delayed trailing gold and white flashes	(c)
Spheroidal (–400 mesh, 5 micron)	Large salutes Metal fuel in stars, etc.	Sound (Report) Flame brightening	(b) (d)

er aluminum metal powders has been appended to this article.

Table 3 Note (a) — Comet Effect — Trailing Sparks

If the aluminum powder used consists of particles that are large enough or well enough protected so they are not completely consumed in a flame, the burning aluminum particles will leave the flame as trailing white sparks.[4] To some extent the size of the aluminum particles is related to the duration of the sparks, with larger particles offering the potential for longer duration effects. In this application, the use of a wide range of particle sizes can be effective by producing a range of both long- and short-duration burning sparks, thus producing a denser trail of sparks that fade gradually along the length of the comet tail. If the oxidizer used is not capable of igniting coarser atomized aluminums, then a large flake aluminum may have to be used. This type of trailing spark effect is commonly described as a "flitter" effect.[5]

There is an interesting related effect in which a significant delay occurs between the burning of a star that produces golden charcoal sparks and the first appearance of silver aluminum sparks.[6] This effect is commonly termed a "firefly", "transition", or "transformation" effect. In these comet stars, generally fine flitter flakes are used.

Table 3 Note (b) Salute — Flash / Sound Compositions

Making any pyrotechnic composition can be dangerous to prepare and use, because of the possibility of accidental ignitions and the resulting thermal and/or explosive effects. However, because some flash formulas include components rendering them quite sensitive, and because the magnitude of the output from flash powder is particularly large, great care must be exercised during its preparation and use. The smallest particle size, and therefore most reactive, aluminum metal powders should be avoided except when absolutely necessary to obtain a given effect.

When choosing an aluminum powder for use in salutes, reactivity is obviously an important, but not the only, consideration. Obvious choices for high reactivity are the 36-, 13-, and 3-micron flake aluminum powders, and the 5-micron spheroidal aluminum powder. Probably the 3 micron flake aluminum (German dark) is the aluminum powder of choice for the smallest exploding items (e.g., the break-charge for crossettes and for salutes <½" in diameter). However, cost can be a factor in limiting its use.

Density can be another consideration in selecting an aluminum powder. High density powders such as atomized aluminum allow loading a greater weight of composition into a given volume, thus potentially producing a greater effect. However, a problem with compositions containing atomized aluminums sometimes arises because of their tendency to compact with time. Compacted flash compositions tend to burn more slowly which can render them much less effective. However, the addition of a small percentage of fine flake aluminum or a bulking agent such as bran can help prevent compaction problems. Also the use of a mixture of flake and atomized aluminum has been reported to be a particularly effective combination for flash powders.[7]

For large salutes and salutes with strong cases, reactivity is not as important as it is for smaller, more weakly encased salutes. For larger salutes it is just as effective to use safer and less expensive aluminums with larger particle sizes. In part, this is because reaction rates dramatically increase as pressure increases. Thus a stronger case over comes the lower intrinsic reactivity of larger particles by allowing pressures and reaction rates to build before the case ruptures. In a somewhat similar fashion, in large salutes, pressures can rise to higher values because of an effect termed inertial confinement.[8]

For a more complete discussion of the preparation and use of flash compositions, see References 9 and 10. For information on some safety problems with flash powders and other metal fuel compositions, see Reference 11.

Table 3 Note (c) Glitter Effect — Trailing Delayed Flashes

In glitter, the reactivity of the aluminum metal powder can play a role in determining the color (gold — yellow — white) of the flashes. Fine flake aluminum powder (<40 micron) often produces yellowish-gold glitter flashes, even in the absence of a sodium salt. On the contrary, large atomized aluminum powder (10–20 micron) often produces yellowish-white flashes even when a sodium salt is present. It has been hypothesized[2] that this is a result of differing flash temperatures. The more reactive fine flake aluminum flashes at a lower temperature, tending to produce a yellow glitter flash even without sodium. Whereas the less reactive large atomized aluminum requires a higher temperature to flash, producing a brilliant white flash that can only be turned yellowish-white by the presence of sodium. When even larger particles of aluminum (such as 30 micron spherical, atomized) are used in glitter formulations, burning particles of aluminum will be propelled from the glitter flashes. This produces a very delicate effect at close range, that one is tempted to call flittering-glitter. Winokur[2] stated that it is possible to produce a similar effect using a mixture of different aluminum powders.

Spherical, atomized aluminum seems to produce distinctly superior glitter (large puffy flashes that are more brilliant) when compared with those produced by spheroidal atomized aluminum. Fish[12] hypothesized that the reason may be the lower and more uniform reactivity of spherical aluminum. The lower reactivity might delay the onset of a glitter flash until more glitter-flash-oxidizer (potassium sulfate) is produced. This might cause the flash to be more violent (larger, puffier) when it does occur. Also, this might result in flashes that are more energetic which would be more brilliant. It would be remiss to leave the impression that the shape of atomization is the single controlling factor in producing excellent glitter. There are many other important factors, but their discussion is beyond the scope of this article. For more information see references 5, 13, and 14.

Table 3 Note (d) Metal Fuel — Flame Brightening

The use of metal fuels in star formulations increases the amount of energy produced during burning. Some of this extra energy can be used to vaporize additional amounts of color generating salts included in the star composition. This can have the effect of producing more deeply colored flames. Also some of the extra energy produced can be left to increase the flame temperature, thus providing additional energy for the light generating process. This has the effect of producing brighter colored flames.

Aluminum is a reasonably good metal fuel for flame brightening; its chief competitors are magnesium and magnalium (magnesium / aluminum alloy). Aluminum is the safest to use and is cheaper than either magnesium or magnalium. The use of aluminum as a color star fuel tends to make the flame appear opaque. This can be a desirable quality. However, it also adds white light to colored flames, which acts to washout the color somewhat. This is caused by the formation of aluminum oxide particles which then incandesce in the flame. The use of magnesium, in conjunction with sufficient chlorine donor, does not produce this oxide effect, and therefore can produce colored flames of higher purity. However, the use of magnesium as a flame brightening fuel can present significant safety problems. For a more complete discussion of the use of metal fuels in colored flame compositions, see Reference 15.

In choosing an aluminum fuel, one should select the least expensive aluminum that contains particles small enough to be completely consumed in the flame. This is because the production of a small number of short-lived, trailing silver sparks has a most unpleasing appearance. Note that the authors have not found it possible to satisfactorily produce both flame brightening and a silver comet tail by use of a large-particle aluminum powder. When this has been attempted, the color of the star seriously degrades before a tail of pleasing density has been achieved. The use of titanium metal powder is the answer to produce such an effect.[16] Finally, in attempting to brighten flames, one should avoid using flake aluminum (it is too messy) and extremely fine aluminum (it is more reactive than necessary, and therefore less safe).

Acknowledgments

The authors gratefully acknowledge the information supplied by D. Tygett of Valimet and C.K. Campbell of Alcan-Toyo America, and the suggestions and comments of R.L. Winokur and M. Swisher. Also, M. Swisher was kind enough to supply the additional information on aluminum powders included as an Appendix.

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Appendix

[M. Swisher supplied the following information on other aluminum powders in mid-1991.]

Notes on German Aluminums

The names "black head", blue head and "yellow head" are designations applied by Hummel Chemical Co. in its catalogue to German aluminums sold by that firm. It should be noted that Hummel is not the manufacturer and these are not the manufacturer's terms. I believe these aluminums are made by Gloria Bronzefarbewerke, which has a much more extensive line of powdered aluminums than just these three. They designated their products, as do US manufacturers, by part numbers. I have seen their information in the past. I do not, however, have anything in my files from them.

The term "pyro" aluminum originally came from the manufacturing process, not from the intended pyrotechnic use. Several methods are used; the foiled paper being burnt then milled, which the Kosankes mentioned is one; in another, aluminum is milled with stearin but then baked in a vacuum to decompose the stearin. I do not know the others. The particle shape produced depends upon the method used. (This information comes from Dr. Mike Stanbridge via Jerry Taylor.)

Notes on Other Aluminum Grades Used in Fireworks

One of the most commonly used atomized grades is Reynolds #120. I have, in my experience, found this to be one of the best and most versatile aluminums for tremalons (flitter, glitter).

A grade I have seen once or twice, but do not know the origins of, is described as "sparkler grade". In appearance it is neither atomized nor a ball-milled flake. It seems to be somehow mechanically comminuted, by some type of grinding process.

Final Note

Those wishing to avoid ambiguity in the description of aluminum powders have really only one choice. That is to use the manufacturer's name and part number. Most serious manufacturers of fireworks do this in their private formularies. Even so, the natural variability of the product is sometimes defeating. In a drum of US Bronze #812 "coarse flitters" you will find finer material at the bottom than you will find in the top of a drum of their #813 "fine flitters". Flitters have a way of stratifying, and also the individual flakes break down from larger to smaller as the aluminum is stirred, moved, or mixed. In a case where flitters are used, and the effect depends upon precise particle sizing, there is often no choice but to undertake a laborious process to separate the desired "cut". I have found this necessary, for example, in making the charcoal-aluminum star.

Descriptive Table of German Manufactured Aluminum Products.

Hummel Designation	Description	Use
"Black head"	The black aluminum (as distinct from dark); "alluminio nero"	Flash powder
"Blue head"	A dark grade which could be called an "alluminio scuro", in practice something like a 50:50 mixture of black head with USB #809	Salutes, illuminating stars
"Yellow head"	The sample I saw was a "bright" grade but was denser than (e.g., USB #808 or #810).	Electric and tremalon stars, gerbs, falls, etc.

Descriptive Table of Customary Identifications and US Aluminum Bronze Product Numbers.

US Bronze No.	Description	Use
809	"dark", the "alluminio scuro" of the Italians	flash powders, strong white and yellow stars, some tremalons
808	"light pyro" or "bright"— the "alluminio bianco" of the Italians	silver stars with chlorate or perchlorate ("electric" stars), some tremalons
810	"bright" (coarser than #808) ("alluminio brillante")	silver ("electric") stars; rosette powder, fountains, some tremalons
813	fine "flitters" (20–80 mesh) "alluminio in scagile"	silver ("electric") stars, fountains, falls, charcoal/aluminum stars
812	coarse "flitters" (10–30 mesh)	gerbs, falls, too coarse to put in cut stars